Appl. No. 10/656,185
Amendment dated August 19, 2004
Reply to Office Action of March 19, 2004

IN THE CLAIMS

This listing of claims will replace all prior versions, and listings, of claims in the application:

Claim 1 (Currently Amended): A supersensitive nuclear magnetic resonance (NMR) imaging apparatus comprising:

a sample chamber positioned to receive a biosample for image analysis at a predetermined spatial resolution;

a superconducting magnet formed of laterally divided spit magnets, and a gradient magnetic field coil arranged to generate a gradient magnetic field in a horizontal direction for irradiation to the biosample in the sample chamber; and~~,~~

~~a high frequency emitting coil, and~~

~~a receiving coil,~~ a solenoid type detection antenna arranged to detect a NMR signal obtained from the sample under irradiation of the gradient magnetic field for image analysis.

wherein ~~a~~the biosample, including at least one of cells, organic tissues, and laboratory small animals, is inserted in ~~a~~the sample chamber of generally 1 to 30 mm in diameter at a center of the gradient magnetic field, ~~the superconducting magnet is formed of laterally divided split magnets, the direction of the magnetic field generated by said magnet is generally horizontal, the receiving coil is in the form of a solenoid coil, the biosample is inserted~~ from a direction orthogonal to the direction of the magnetic field ~~in a generally vertical direction~~, and position information is applied to the NMR signal by the gradient magnetic field ~~and the spatial resolution in imaging of the biosample is not more than one tenth of a cell that forms the biosample~~.

Claim 2 (Currently Amended): A supersensitive nuclear magnetic resonance imaging apparatus according to Claim 1, wherein a stationary magnetic field generated by the superconducting magnet is not ~~less than 11 T, and more preferably, not~~ less than 14.1 T, variations per hour in Proton nuclear magnetic resonance frequencies due to variations in the stationary magnetic field is not more than 1.0 Hz, and the uniformity of the stationary magnetic field in ~~the~~a sample space is not more than 1.0 Hz in Proton nuclear magnetic resonance frequencies.

Claim 3 (Currently Amended): A supersensitive nuclear magnetic resonance imaging apparatus according to Claim 1, wherein the ~~imaging~~predetermined spatial resolution is not more than 1 micron.

Claim 4 (Currently Amended): A supersensitive nuclear magnetic resonance imaging apparatus ~~according to Claim 1,~~comprising:

a sample chamber positioned to receive a biosample for image analysis at a predetermined spatial resolution;

a superconducting magnet formed of laterally divided spit magnets, and a gradient magnetic field coil arranged to generate a gradient magnetic field in a horizontal direction for irradiation to the biosample in the sample chamber; and

a receiving coil arranged to detect a NMR signal obtained from the sample under irradiation of the gradient magnetic field for image analysis.

wherein the biosample, including at least one of cells, organic tissues, and laboratory small animals, is inserted in the sample chamber of generally 1 to 30 mm in diameter at a center of the gradient magnetic field, from a direction orthogonal to the direction of the magnetic field, and

wherein the receiving coil is formed of one of oxide high temperature superconducting material~~, or of~~ and magnesium diboride, and ~~the~~ coil temperatures are between 5 K and 40 K inclusive.

Claim 5 (Currently Amended): A supersensitive nuclear magnetic resonance imaging apparatus according to Claim 2, wherein ~~imaging~~the predetermined spatial resolution is not more than 1 micron.

Claim 6 (Currently Amended): A supersensitive nuclear magnetic resonance imaging apparatus according to Claim 2, ~~transmission of~~wherein protein information ~~network information~~ in ~~the~~ organic tissues of the biosample can be imaged as two-dimensional or three-dimensional image information.

Claim 7 (Currently Amended): A supersensitive nuclear magnetic resonance imaging apparatus ~~according to Claim 2,~~comprising:

a sample chamber positioned to receive a biosample for image analysis at a predetermined spatial resolution;

a superconducting magnet formed of laterally divided spit magnets, and a gradient magnetic field coil arranged to generate a gradient magnetic field in a horizontal direction for irradiation to the biosample in the sample chamber; and

a receiving coil arranged to detect a NMR signal obtained from the sample under irradiation of the gradient magnetic field for image analysis,

wherein the biosample, including at least one of cells, organic tissues, and laboratory small animals, is inserted in the sample chamber of generally 1 to 30 mm in diameter at a center of the gradient magnetic field, from a direction orthogonal to the direction of the magnetic field;

wherein a stationary magnetic field generated by the superconducting magnet is not less than 14.1 T, variations per hour in Proton nuclear magnetic resonance frequencies due to variations in the stationary magnetic field is not more than 1.0 Hz, and the uniformity of the stationary magnetic field in a sample space is not more than 1.0 Hz in Proton nuclear magnetic resonance frequencies; and

wherein the receiving coil is formed of one of oxide high temperature superconducting material~~, or of~~ and magnesium diboride, and ~~the~~ coil temperatures are between 5 K and 40 K inclusive.

Claim 8 (Currently Amended): A supersensitive nuclear magnetic resonance imaging apparatus ~~according to Claim 3,~~ comprising:

a sample chamber positioned to receive a biosample for image analysis at a predetermined spatial resolution;

a superconducting magnet formed of laterally divided spit magnets, and a gradient magnetic field coil arranged to generate a gradient magnetic field in a horizontal direction for irradiation to the biosample in the sample chamber; and

a receiving coil arranged to detect a NMR signal obtained from the sample under irradiation of the gradient magnetic field for image analysis.

wherein the biosample, including at least one of cells, organic tissues, and laboratory small animals, is inserted in the sample chamber of generally 1 to 30 mm in diameter at a center of the gradient magnetic field, from a direction orthogonal to the direction of the magnetic field;

wherein the predetermined spatial resolution for image analysis of the biosample is not more than 1 micron; and

wherein the receiving coil is formed of one of oxide high temperature superconducting material, ~~or of~~and magnesium diboride, and ~~the~~ coil temperatures are between 5 K and 40 K inclusive.

Claim 9 (Currently Amended): A supersensitive nuclear magnetic resonance (NMR) imaging apparatus comprising:

a sample chamber positioned to receive a protein sample for image analysis at a predetermined spatial resolution;

a superconducting magnet formed of laterally divided split magnets, and a gradient magnetic field coil arranged to generate a gradient magnetic field in a horizontal direction for irradiation to the protein sample in the sample chamber;~~,~~ and

~~a high frequency emitting coil, and~~

a ~~receiving coil~~solenoid type detection antenna arranged to detect a NMR signal obtained from the protein sample under irradiation of the gradient magnetic field for image analysis,

wherein ~~a~~the protein sample dissolved into liquid ~~water or the like~~ is inserted into a sample tube, ~~the superconducting magnet is formed of laterally divided split magnets, the direction of the magnetic field generated by said magnet is generally~~

~~horizontal, the receiving coil is in the form of a solenoid coil, the sample is inserted~~ and placed in the sample chamber from a direction orthogonal to the direction of the gradient magnetic field~~ in a generally vertical direction~~, a ~~high quality~~ protein crystal can be grown in the gradient magnetic field, the predetermined spatial resolution ~~being sufficient for observing~~is obtained for observation of the surface property of the protein crystal when the protein dissolved in the liquid is crystallized, ~~the~~a growing velocity and a growing surface of the crystal can be observed on site by the nuclear magnetic resonance imaging, and ~~the~~ crystal growth conditions can be ~~adequately~~ controlled by obtained information.

Claim 10 (Currently Amended): A supersensitive nuclear magnetic resonance imaging apparatus according to Claim 9, wherein a stationary magnetic field generated by the superconducting magnet is not ~~less than 11 T, and more preferably, not~~ less than 14.1 T, variations per hour in Proton nuclear magnetic resonance frequencies due to variations in the stationary magnetic field is not more than 1.0 Hz, and the uniformity of the stationary magnetic field in ~~the~~a sample space is not more than 1.0 Hz in Proton nuclear magnetic resonance frequencies.

Claim 11 (Currently Amended): A supersensitive nuclear magnetic resonance imaging apparatus according to Claim 9, wherein the ~~imaging~~predetermined spatial resolution is not more than 1 micron.

Claim 12 (Currently Amended): A supersensitive nuclear magnetic resonance imaging apparatus according to Claim 9, wherein ~~transmission of~~ protein

information ~~network information~~ in ~~the~~ organic tissues of the protein sample can be imaged as two-dimensional or three-dimensional image information.

Claim 13 (Currently Amended): A supersensitive nuclear magnetic resonance imaging apparatus ~~according to Claim 9,~~ comprising:

a sample chamber positioned to receive a protein sample for image analysis at a predetermined spatial resolution;

a superconducting magnet formed of laterally divided split magnets, and a gradient magnetic field coil arranged to generate a gradient magnetic field in a horizontal direction for irradiation to the protein sample in the sample chamber; and

a receiving coil arranged to detect a NMR signal obtained from the protein sample under irradiation of the gradient magnetic field for image analysis,

wherein the protein sample dissolved into liquid is inserted into a sample tube, and placed in the sample chamber from a direction orthogonal to the direction of the gradient magnetic field, a protein crystal can be grown in the gradient magnetic field;

wherein the predetermined spatial resolution is obtained for observation of the surface property of the protein crystal when the protein dissolved in the liquid is crystallized, a growing velocity and a growing surface of the crystal can be observed on site by the nuclear magnetic resonance imaging, and crystal growth conditions can be controlled by obtained information; and

wherein the receiving coil is formed of one of oxide high temperature superconducting material, ~~or of~~ and magnesium diboride, and ~~the~~ coil temperatures are between 5 K and 40 K inclusive.

Claim 14 (Currently Amended): A supersensitive nuclear magnetic resonance imaging apparatus according to Claim 10, wherein ~~imaging~~the predetermined spatial resolution is not more than 1 micron.

Claim 15 (Currently Amended): A supersensitive nuclear magnetic resonance imaging apparatus according to Claim 10, ~~transmission of~~wherein protein information ~~network information~~ in ~~the~~ organic tissues of the protein sample can be imaged as two-dimensional or three-dimensional image information.

Claim 16 (Currently Amended): A supersensitive nuclear magnetic resonance imaging apparatus ~~according to Claim 10,~~comprising:

a sample chamber positioned to receive a protein sample for image analysis at a predetermined spatial resolution;

a superconducting magnet formed of laterally divided split magnets, and a gradient magnetic field coil arranged to generate a gradient magnetic field in a horizontal direction for irradiation to the protein sample in the sample chamber; and

a receiving coil arranged to detect a NMR signal obtained from the protein sample under irradiation of the gradient magnetic field for image analysis,

wherein the protein sample dissolved into liquid is inserted into a sample tube, and placed in the sample chamber from a direction orthogonal to the direction of the gradient magnetic field, a protein crystal can be grown in the gradient magnetic field, the predetermined spatial resolution is obtained for observation of the surface property of the protein crystal when the protein dissolved in the liquid is crystallized, a growing velocity and a growing surface of the crystal can be observed on site by

the nuclear magnetic resonance imaging, and crystal growth conditions can be controlled by obtained information;

wherein a stationary magnetic field generated by the superconducting magnet is not less than 14.1 T, variations per hour in Proton nuclear magnetic resonance frequencies due to variations in the stationary magnetic field is not more than 1.0 Hz, and the uniformity of the stationary magnetic field in a sample space is not more than 1.0 Hz in Proton nuclear magnetic resonance frequencies; and

wherein the receiving coil is formed of one of oxide high temperature superconducting material~~, or of~~and magnesium diboride, and ~~the~~ coil temperatures are between 5 K and 40 K inclusive.

Claim 17 (Currently Amended): A supersensitive nuclear magnetic resonance imaging apparatus ~~according to Claim 11,~~ comprising:

a sample chamber positioned to receive a protein sample for image analysis at a predetermined spatial resolution;

a superconducting magnet formed of laterally divided split magnets, and a gradient magnetic field coil arranged to generate a gradient magnetic field in a horizontal direction for irradiation to the protein sample in the sample chamber; and

a receiving coil arranged to detect a NMR signal obtained from the protein sample under irradiation of the gradient magnetic field for image analysis,

wherein the protein sample dissolved into liquid is inserted into a sample tube, and placed in the sample chamber from a direction orthogonal to the direction of the gradient magnetic field, a protein crystal can be grown in the gradient magnetic field;

wherein the predetermined spatial resolution is not more than 1 micron, enabling observation of the surface property of the protein crystal when the protein dissolved in the liquid is crystallized, a growing velocity and a growing surface of the crystal can be observed on site by the nuclear magnetic resonance imaging, and crystal growth conditions can be controlled by obtained information; and

wherein the receiving coil is formed of one of oxide high temperature superconducting material~~, or of~~and magnesium diboride, and ~~the~~ coil temperatures are between 5 K and 40 K inclusive.